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REPORT

ON

THE FLOODS OF THE MOIRA RIVER,

AT

BELLEVILLE, ONT.

APRIL, 1920.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS
MONTREAL.

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO

April 30th, 1920.

J. M. R. Fairbairn, Esq.,

Chief Engineer, Canadian Pacific Railway,

M O N T R E A L.

A. F. Stewart, Esq.,

Chief Engineer, Canadian National Railways,

T O R O N T O.

COPY

re Floods at Belleville, Ont.

Gentlemen,-

In accordance with instructions received from Mr. Fairbairn, we made a detailed investigation of the condition of the Moira River at Belleville during the springtime of 1920. We now beg to transmit herewith our report which we trust you may find in order, and which describes in full detail the flood that occurred in March.

For your convenience we may say briefly that we have come to the conclusion that the Railway Bridge is in no way responsible for the flood, and that the embankment immediately to the west of the bridge did not materially aggravate the flood conditions of this year.

We recommend that additional openings be provided in this embankment and that an area be kept free from ice in the neighbourhood of the Railway

Bridge.

The reasons leading us to these conclusions and recommendations are dealt with in the body of the report, and the conclusions and recommendations themselves are summarized in the last two pages thereof.

We wish to thank you for having entrusted us with this service.

Yours very truly,

Walter J. Francis & Company,

per Frederick B. Brown

I N D E X

REPORT

on

THE FLOODS OF THE MOIRA RIVER

at

BELLEVILLE, ONT.

April, 1930

Walter J. Francis & Company
Consulting Engineers
Montreal

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS, (Continued)

LIST OF ILLUSTRATIONS, (Concluded)

Chapter I

Instructions and Field Work

In accordance with instructions received on January 19th, 1920, from Mr. J. M. R. Fairbairn, Chief Engineer of the Canadian Pacific Railway, we immediately commenced an investigation of the flooding conditions of the Moira River at Belleville, Ont. Our Principal Assistant, Mr. J. L. Busfield, A.M.E.I.C., left for Belleville making a preliminary examination of the river on January 20th, and on January 23rd met Messrs. MacMurchy, Humphrey, Ripley and Rudder, of the Canadian Pacific Railway and went into the details of the whole situation, receiving a number of photographs, plans and evidence from Mr. MacMurchy.

In view of the possibility of floods occurring at any time during the winter months, members of our staff forthwith commenced a survey and detailed investigation of the ice conditions in the Moira River and Bay of Quinte, which work was carried on continuously until the floods occurred during the fourth week in March. In order that no unnecessary work should be performed, the surveys during the period previous to the flood were confined to the recording of those conditions which could not be determined after the ice had broken up.

On February 13th the writer accompanied Mr. Busfield to Belleville and there met Mr. MacMurchy and Lt.-Col. Ponton, and in company with them interviewed City Engineer Mill and a number of old residents familiar with local

conditions.

Following certain resolutions passed by the City Council of Belleville, Mr. Busfield attended a meeting of the City Officials with Mr. MacMurchy and engineers of the Canadian Pacific and Canadian National Railways, and of the Department of Public Works of Canada, and at this meeting he advised the City Authorities present that the railways admit no responsibility with regard to the flooding, and, therefore, could not contribute towards any expenditures they might make in order to mitigate the conditions.

During the critical period of the flood we had a staff of assistants and a moving-picture operator keeping an exact record of the progress of events throughout each day and night, and our Mr. Brown went to Belleville and examined conditions during the height of the flood on March 22nd. After the flood the surveys were continued in order to obtain the natural topographical features of the flooded territory, and such other essential information as had not been acquired prior to the flood. The information and data thus obtained have been carefully studied and form the basis of this report.

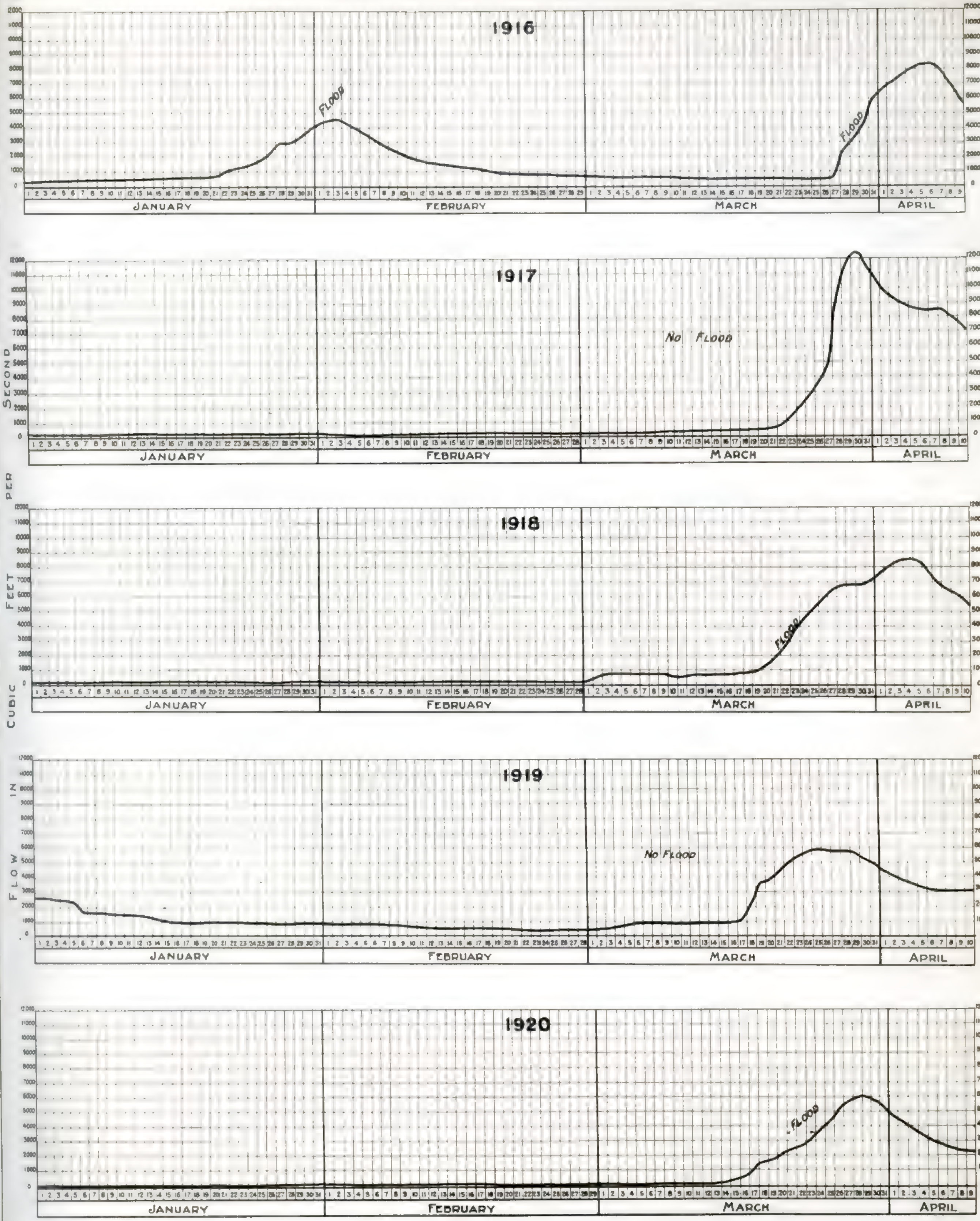
Chapter II

Description of the River and Locality

The River.

The Moira River drains a watershed of 1,038 square miles. It has a minimum flow of less than 100 cubic feet per second, and a maximum of over 12,000 cubic feet per second. The latter quantity is only occasionally reached, and never lasts for a protracted period. The condition of the upper reaches of the river, having no bearing on the flooding situation, we have made no examination of them, but have confined ourselves to that portion of the river south of Foxboro, comprising a length of about 8½ miles.

At Foxboro there is situated a gauging station, installed in 1915 by the Hydro-Electric Power Commission of Ontario, but now operated by the Water Power Branch of the Dominion Government. Through the courtesy of the officials of the latter Department we have obtained the daily readings taken at this station. Twice daily during the flood period, and for some time previous, we were advised, under special arrangements, of the gauge readings at Foxboro. The flow of the river during the months of January, February, March and part of April in the years 1916 to 1920 inclusive, is shown on the diagram included as page 4. It will be particularly noted from this diagram that a large run-off in the spring does not necessarily create flood conditions at Belleville.



Note - The above diagrams are based on Gauge readings obtained at FOXBORO, ONT.

MOIRA RIVER, BELLEVILLE, ONT.

DISCHARGE IN CUBIC FEET PER SECOND
JANUARY 1ST TO APRIL 10TH OF THE YEARS
1916 TO 1920

Scales as shown

Made by HDB *Checked by* J.

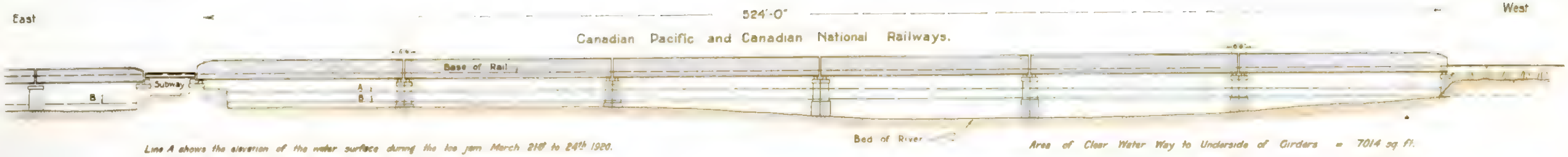
Montreal, 20 April 1920
Walter J. Francis & Company, Engineers,
260 St James Street, Montreal

From above Foxboro to Corbyville (about four miles below Foxboro) the river is sluggish, this section being referred to locally as the "dead water". Immediately above the village of Corbyville there is a small rapid, and from this point the water flows swiftly until the Lower Bridge at Belleville is reached, at a distance of about 4½ miles from Corbyville. There are four dams between Corbyville and the Bay, namely at Cannifton, 1½ miles below Corbyville; at Lazier's Mill, 2¾ miles; Lott's Dam, 3¾ miles, or ¼ mile above the Upper Bridge at Belleville; and Cooper's Dam 4-1/8 miles, or 1/8 mile below the Upper Bridge. The total fall of the river from the dead water to the Bay of Quinte is about 80 feet. in ~~8~~ miles in 4½ ms

The bed of the stream has a good slope until the neighbourhood of the Foot Bridge and Lower Bridge is reached. From a point midway between these bridges to another point just below the Railway Bridge there is practically no natural fall, but on the westerly side of the river a channel about six feet deep extending about 300 feet north of the Railway Bridge was dredged by the Dominion Government in 1887 and 1890. The soundings in the lower part of the river and in the Bay of Quinte across the mouth of the river are shown on the plan included as page 30.

The Locality.

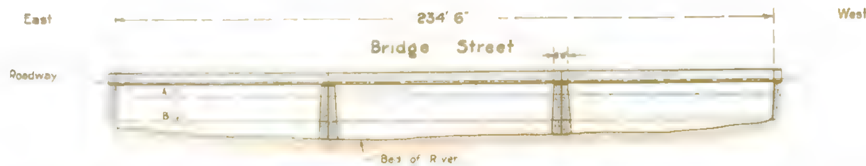
On the west side of the river that portion of the City of Belleville most seriously affected by floods lies south of Bridge Street, and is between the river and the high bank about 1,000 feet to the west thereof. This area has a number of streets and is occupied by comparatively inexpensive houses.



Line A shows the elevation of the water surface during the ice jam March 21st to 24th 1920.
Line B shows the elevation of the average surface of the ice during Mid-Winter 1919-1920.

Area of Clear Water Way to Underside of Girders	=	7014 sq ft.
" " " " " " Line A	=	4315
" " " " " " Line B	=	2387 "

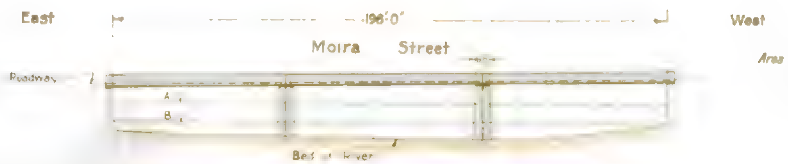
Railway Bridge Looking Downstream



Line A shows the elevation of the water surface during the ice jam March 21st to 24th 1920.
Line B shows the elevation of the average surface of the ice during Mid-Winter 1919-1920.

Area of Clear Water Way to Underside of Girders	3898 sq ft
" " " " " " Line A	3066
" " " " " " Line B	1114

Lower Bridge Looking Downstream



Area of Clear Water Way to Underside of Girders	=	3318 sq ft
" " " " " " Line A	=	2178
" " " " " " Line B	=	1074

Line A shows the elevation of the Water surface during the ice jam March 17th to 21st 1920
Line B shows the elevation of the average surface of the Ice during Mid Winter 919-1920

Upper Bridge Looking Downstream

(9)

Moira River, Belleville, Ont.

Cross Sections of Railway and Highway Bridges in the City of Belleville

1920

Scale of Feet.

Made by YLB Checked by F.

Montreal, 20 April 1920

Walter J Francis & Company, Engineers,
260 St James Street, Montreal

North of Bridge Street the limit of the floods has extended as far north as Catherine Street and west to Cedar Street. This area is occupied by a fairly good class of houses but is not so seriously affected as the area south of Bridge Street. Neither of these areas are more than five or six feet higher than the average water level of the river.

On the east side, Front Street, the main street of the city, parallels the river, but with the exception of the southerly portion is high enough to be above the flood level. The sheds and stables at the rear of the stores, and the cellars are on a considerably lower level and are periodically subjected to floods. The south end of Front Street is occupied by a miscellaneous collection of stores and buildings, most of which are of poor construction. The low-lying area south of the City Hall and east of Front Street, occupied by stables and sheds, is also periodically subjected to floods.

Within the City of Belleville the river is crossed by four bridges - the Upper Bridge at Moira Street; the Foot Bridge at Catherine Street; the Lower Bridge at Bridge Street; and by the Railway Bridge, carrying the Canadian Pacific and Canadian National Railways. Cross-sections of the bridges, with the exception of the Foot Bridge, are shown on the drawing included as page 6.

The Upper Bridge has three spans, 65 feet, 70 feet, and 61 feet, with two masonry piers 6½ feet wide. The clear waterway below the underside of the girders is 3,318 square feet.

The Foot Bridge is a suspension bridge and has no piers in the river.

To face page 8.

Photograph No. 1.

Upstream Side of Lower Bridge,

Looking West from East End.

Taken February 3, 1920.

Photograph No. 2.

View Looking Upstream,

from the Center of the Lower Bridge.

Taken February 3, 1920.

The Lower Bridge has three spans, 59 feet, 64 feet and 62 feet in the clear, with two masonry piers 6 feet wide. The clear waterway below the underside of the girders is 3,898 square feet. The upstream side is shown in photograph No. 1, while a view looking upstream from this bridge, with the Foot Bridge in the background, is shown in photograph No. 2, both on page 8.

The Railway Bridge consists of two independent pairs of main girders, one carrying the Canadian Pacific and the other the Canadian National tracks, spanning five piers, each of which is seven feet in width. Each of the six spans has a clear opening of 58 feet. At the east end of the main bridge there are four short spans, three of which are over the northerly end of the easterly channel of the river, and the fourth spans a subway leading to Victoria Park. At the west end the two railways are carried on an embankment about five feet higher than the natural ground level near the bridge, and about two feet higher near Bay Bridge Road. There are two openings through this embankment, namely, a wooden box culvert 3.0 feet high by 3.1 feet wide, about 160 feet west of the bridge, and the Bay Bridge Road culvert with two spans of 21½ feet, situated about 1,400 feet west of the bridge.

Photographs Nos. 3 and 4 included as page 10, show the upstream and downstream sides of the Railway Bridge in typical mid-winter conditions, while No. 5, included as page 11, shows the downstream side of the Railway Bridge looking upstream.

The plan included as page 20 shows the general features of the locality, together with the location, size and elevation of all culverts.

To face page 10.

Photograph No. 3.

Upstream Side of Railway Bridge,

Looking East from West Side.

Taken January 25, 1920

Photograph No. 4.

Downstream Side of Railway Bridge,

Looking West from East Side.

Taken January 26, 1920.

To face page 11.

Photograph No. 5.

Downstream Side of Railway Bridge,

Looking North-West from Dyke.

Taken March 2, 1920.

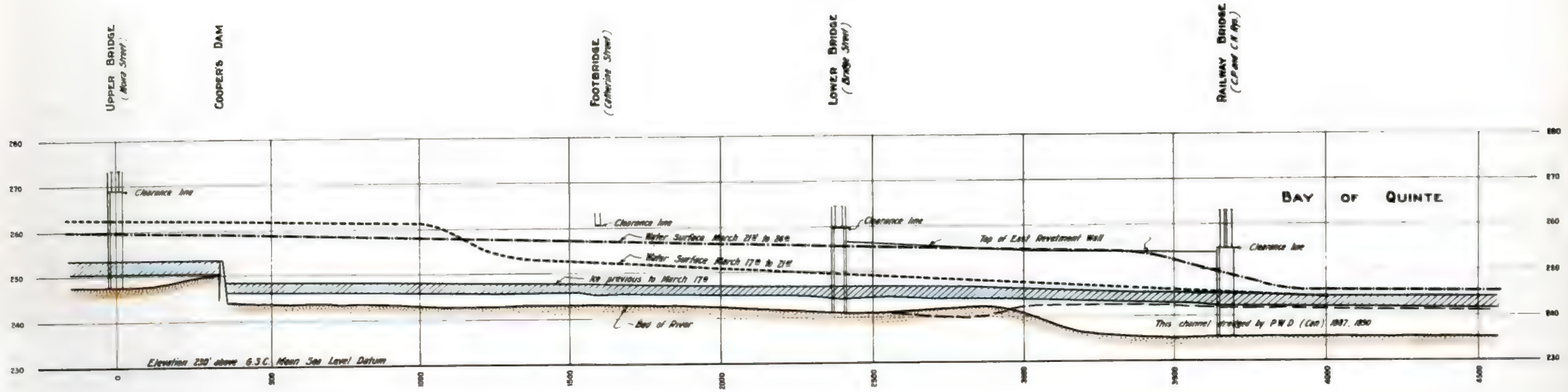
Chapter III

The Flood of 1920

Conditions Prior to the Break-up.

As previously stated, our examination of the conditions in the Moira River commenced during the third week in January, and was carried on continuously until after the flood had occurred. Owing to the very steady low temperature that continued uninterruptedly during the winter months, the Bay of Quinte and the Moira River throughout the City of Belleville were frozen over with ice of exceptionally great thickness. In various places between Cooper's Dam and the Lower Bridge there were narrow channels either entirely open or only lightly frozen over, and in the vicinity of the Railway Bridge an open channel extended almost continuously from about 300 feet north, past the second pier from the east end, thence southerly and westerly through the southerly culvert in the dyke leading to Victoria Park, part of which open channel can be seen in photographs Nos. 4 and 5. There was also an open channel along the west bank of the river.

The thickness of the ice was found to vary from 2 feet to 2 feet 4 inches between Cooper's Dam and the Foot Bridge; from 1 foot 10 inches to 2 feet 3 inches between the Foot Bridge and the Lower Bridge; from 1 foot 8 inches to 2 feet 10 inches between the Lower Bridge and the Railway Bridge, and from 2 feet 10 inches to 2 feet in the Bay of Quinte. At the Lower Bridge



(13)

Moira River, Belleville, Ont.

Profile of River through Belleville showing varying conditions during March 1920

Scales as shown

Made by: JCH Checked by:

Montreal, 10 April 1920

Walter J. Francis & Company, Engineers,
260 St. James Street, Montreal

and the Railway Bridge the thickness averaged about 3 feet. A profile of the river showing the ice in relation to the bed of the river is included as page 13.

Early in March the city authorities cut the ice from around the piers of the Upper Bridge, and commenced to do so at the Lower Bridge, but by the time of the break-up had only cut about three-quarters of the way around the westerly pier. South of the railway bridge they cut a channel 6 feet wide, parallel with the Railway Bridge, and another connecting channel running north and south about 700 feet long. These channels are shown in the photographs Nos. 6 and 7 on page 15, and also on the plan included as page 17. At the Railway Bridge the ice had formed at an elevation considerably higher than the mid-winter level, with the result that the ice between the piers had fallen, breaking away from that attached to the piers.

During the month of February the water flowing in the river was practically confined to a winding channel about 20 feet wide extending from Cooper's Dam to a point about midway between the Lower Bridge and the Railway Bridge, the rest of the bed of the river being filled with anchor or frazil ice. Everywhere south of this point clear water was found below the surface ice. During the early part of March, however, the frazil or anchor ice formed below the surface ice south of the railway bridge, and by the middle of March the mouth of the river was practically entirely blocked with frazil, the water finding its way partly through the culvert in the dyke on the east side of the river, and partly through a narrow channel on the west side.

The flow of the river remained fairly constant at about 160 cubic feet

To face page 15.

Photograph No. 6.

East and West Channel in Bay, Cut by City,

Looking East.

Taken March 18, 1920.

Photograph No. 7.

North and South Channel in Bay, Cut by City,

Looking North.

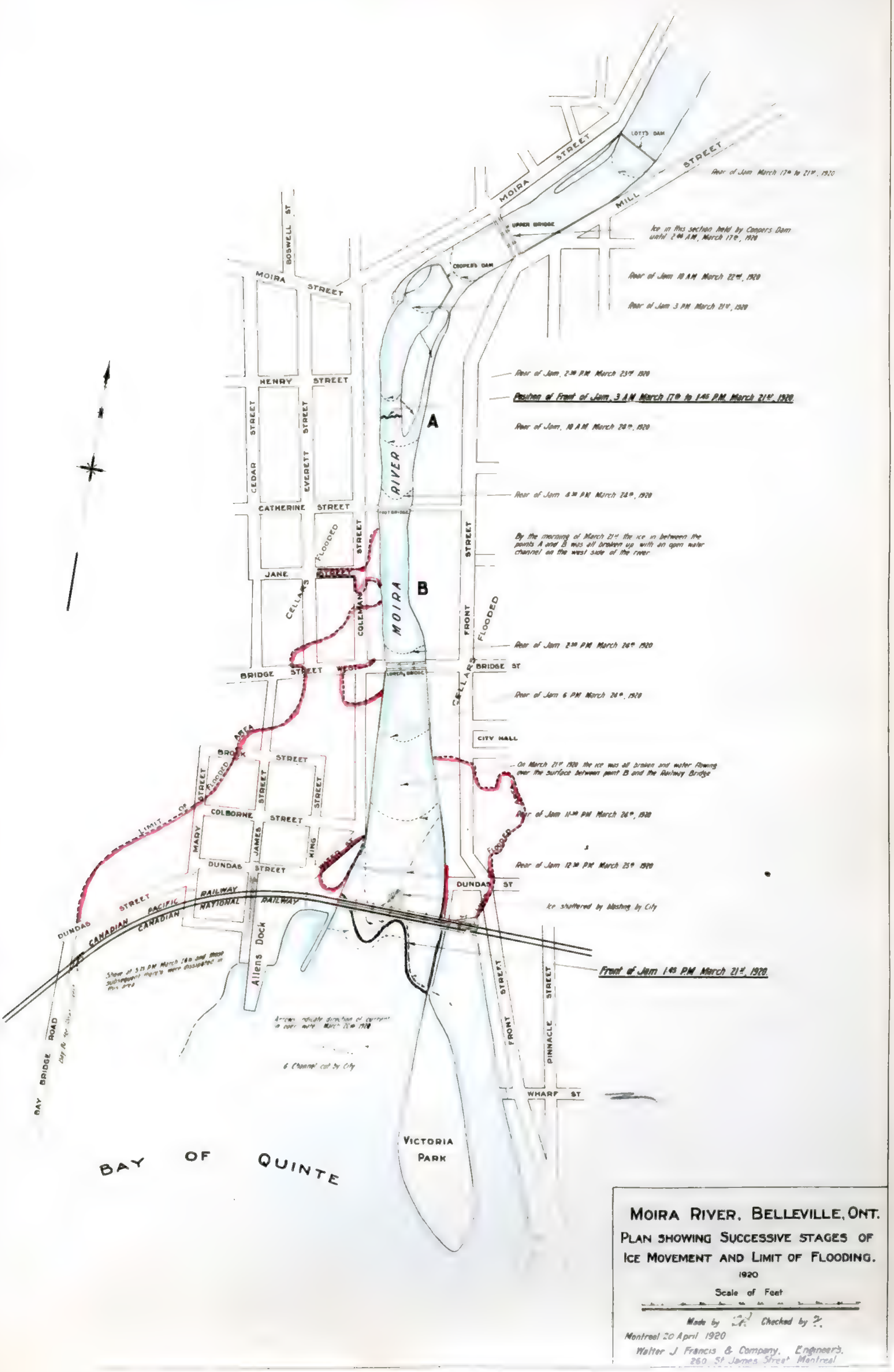
Taken March 18, 1920

per second throughout February and the first week in March, rising to 200 cubic feet per second by March 10th and to 400 cubic feet per second by March 14th. The daily flow is shown on the diagram included as page 4.

<u>The Break-up</u>.

On Tuesday, March 16th, the ice from the river from the upper end of the City of Belleville to Cannifton, had formed a jam with the front end a little above the Upper Bridge, and with the rear immediately below Lott's Dam. The front of the jam was held back by the solid original surface ice which in turn was held by Cooper's Dam, there being insufficient water to raise the ice high enough to pass over this dam. The ice around the piers of the Upper Bridge had been cut away, but the solid ice between the piers was still sufficiently strong to hold back the main jam. This condition remained unchanged until early the following morning. The average flow throughout the day was 700 cubic feet per second.

At 2.45 a.m. on Wednesday, March 17th, the ice held by Cooper's Dam slid over the top permitting the passage of the large body of broken ice above this point. This shove passed downstream until the front end was stopped by the heavy ice at a point about 200 feet south of Henry Street, or 450 feet north of the Foot Bridge, as shown on the plan included as page 17. Considerable quantities of ice had come down at this time from higher up the river, and the rear end of the shove was still about 100 feet below Lott's Dam. Cooper's Dam was entirely drowned out and the water level at


LOTTS DAM
MOIRA STREET
MILL STREET
Rear of Jam March 17th to 21st, 1920
UPPER BRIDGE
Ice in this section held by Coopers Dam until 2 AM, March 17th, 1920
COOPERS DAM
Rear of Jam 10 AM March 22nd, 1920
Rear of Jam 3 PM March 21st, 1920
BOSWELL ST
MOIRA STREET
HENRY STREET
Rear of Jam, 2 PM March 23rd 1920
Position of Front of Jam, 3 AM March 17th to 1.45 PM March 21st, 1920
A
Rear of Jam, 10 AM March 24th, 1920
CEDAR STREET
EVERETT STREET
RIVER
CATHERINE STREET
Rear of Jam 4 PM March 24th, 1920
By the morning of March 21st the ice in between the points A and B was all broken up with an open water channel on the west side of the river
FLOODED
STREET
JANE STREET
CELLARS
B
COLEMAN
MOIRA
FRONT STREET
FLOODED
Rear of Jam 2 PM March 24th 1920
BRIDGE STREET WEST
LOWER BRIDGE
BRIDGE ST
CELLARS
Rear of Jam 6 PM March 24th, 1920
CITY HALL
FLOODED AREA
BROCK STREET
On March 21st 1920 the ice was all broken and water flowing over the surface between point B and the Railway Bridge
LIMIT OF FLOODED
MARY STREET
JAMES STREET
KING STREET
COLBORNE STREET
Rear of Jam 11 PM March 24th, 1920
DUNDAS STREET
FLOODED
Rear of Jam 12 PM March 25th 1920
DUNDAS ST
Ice shattered by blasting by City
DUNDAS STREET
CANADIAN PACIFIC RAILWAY
CANADIAN NATIONAL RAILWAY
Allens Dock
Front of Jam 1.45 PM March 21st, 1920
Arrows indicate direction of current in open water March 21st 1920
Channel cut by City
BAY BRIDGE ROAD
FRONT STREET
PINNACLE STREET
WHARF ST
VICTORIA PARK
BAY OF QUINTE
MOIRA RIVER, BELLEVILLE, ONT.
PLAN SHOWING SUCCESSIVE STAGES OF ICE MOVEMENT AND LIMIT OF FLOODING.
1920
Scale of Feet
Made by Checked by
Montreal 20 April 1920
Walter J. Francis & Company, Engineers,
260 St James Street Montreal

To face page 15.

Photograph No. 8.

View of River, North of the Lower Bridge,

Looking North from McLaughlin Garage.

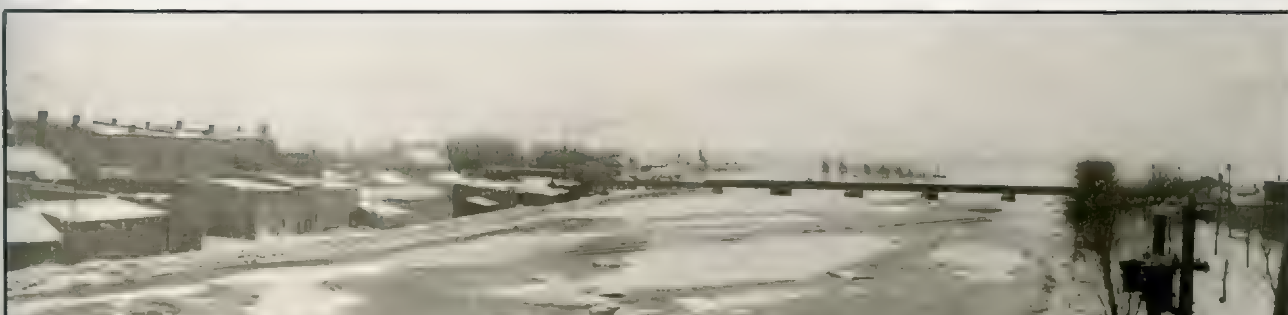
Taken March 20, 1920

Photograph No. 9.

View of River, South of the Lower Bridge,

Looking South from McLaughlin Garage.

Taken March 20, 1920

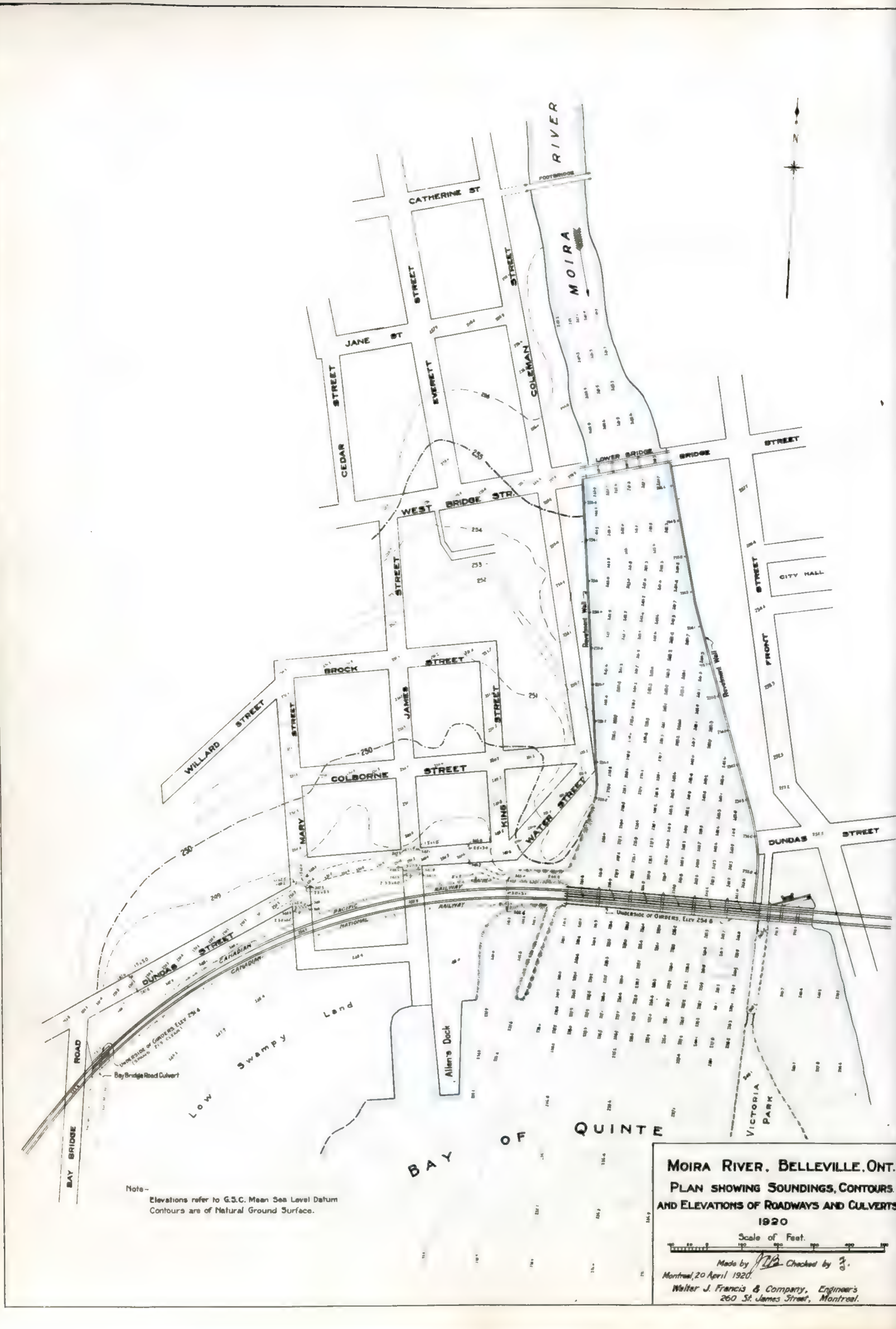


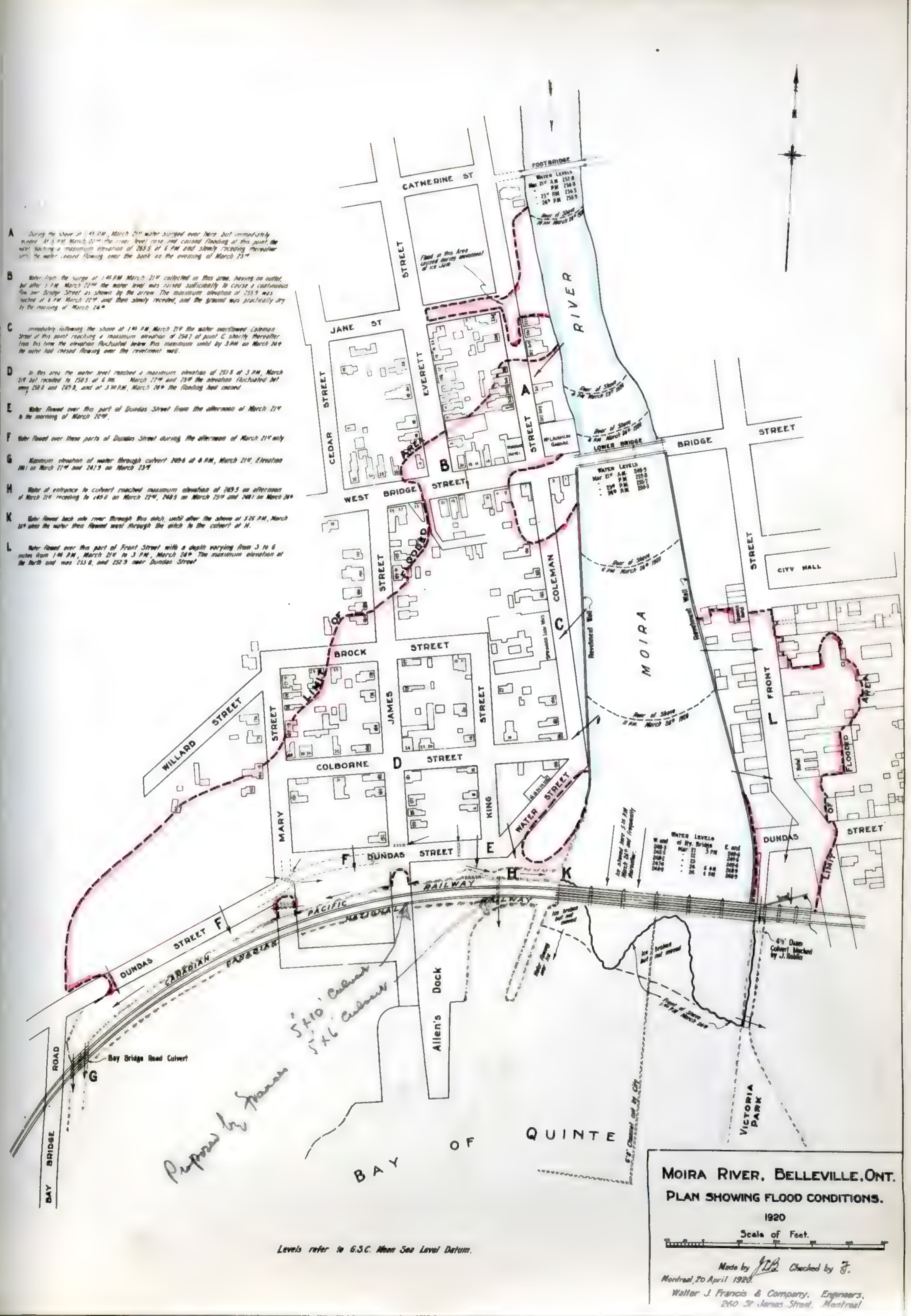
at the Upper Bridge rose about 6 feet, as shown on the profile on page 13. The east side of the jam rested on a low narrow island in the river, and the water was enabled to escape from the side of the jam through the narrow channel between this island and the easterly bank. The water was raised sufficiently to pass over the concrete wall near the vulcanizing works south of the Upper Bridge, flooding the garage on the lower floor, and at the same time there were some cellars and basements in the upper end of the city slightly flooded. Below the front end of the shove the surface of the ice was broken and buckled to a point about 100 feet below the Foot Bridge, permitting the water to flow over the surface in many places, and open channels were formed as far south as the Lower Bridge, below which point there was little change from former conditions. The flow at this time averaged 1,360 cubic feet per second.

The cutting of the channel in the Bay was continued and was approaching close to the Railway Bridge. The city officials also blasted some holes 10 or 15 feet in diameter immediately north of the Railway Bridge.

During Thursday, Friday and Saturday, March 18th, 19th and 20th, there were only minor changes in the situation. The river opened up very considerably in the neighbourhood of the Foot Bridge, and the ice between the Lower Bridge and the Railway Bridge broke up in many places, as shown in photographs Nos. 8 and 9 on page 18, permitting a quantity of water to flow over the surface. The flow of the river steadily increased until by Saturday, March 20th, it averaged 2,200 cubic feet per second.

On Sunday, March 21st, the breaking up of the ice in the neighbourhood of the Foot Bridge continued during the morning, but at 1.45 p.m., the lower


MOIRA RIVER
FOOTBRIDGE
CATHERINE ST
JANE ST
CEDAR STREET
EVERETT STREET
COLEMAN STREET
LOWER BRIDGE
BRIDGE STREET
WEST BRIDGE STR.
STREET
FRONT STREET
CITY HALL
Revetment Wall
BROCK STREET
JAMES STREET
WILLARD STREET
MARY STREET
COLBORNE STREET
KING STREET
WATER STREET
DUNDAS STREET
CANADIAN PACIFIC RAILWAY
CANADIAN NATIONAL RAILWAY
Underside of Girders, Elev 254.8
BAY BRIDGE ROAD
Bay Bridge Road Culvert
Low Swampy Land
Allen's Dock
VICTORIA PARK
BAY OF QUINTE
N
Note-
Elevations refer to G.S.C. Mean Sea Level Datum
Contours are of Natural Ground Surface.
MOIRA RIVER, BELLEVILLE, ONT.
PLAN SHOWING SOUNDINGS, CONTOURS
AND ELEVATIONS OF ROADWAYS AND CULVERTS
1920
Scale of Feet.
Made by
Checked by
Montreal, 20 April 1920.
Walter J. Francis & Company, Engineers
260 St. James Street, Montreal.


A During the shove at 1.45 P.M., March 21st water surged over here but immediately receded. At 5 P.M. March 22nd the river level rose and caused flooding at this point, the water reaching a maximum elevation of 255.5 at 6 P.M. and slowly receding thereafter until the water ceased flowing over the bank on the evening of March 23rd
B Water from the surge at 1.40 P.M. March 21st collected in this area, having no outlet, but after 5 P.M. March 22nd the water level was raised sufficiently to cause a continuous flow over Bridge Street as shown by the arrow. The maximum elevation of 255.9 was reached at 6 P.M. March 22nd and then slowly receded, and the ground was practically dry by the morning of March 24th
C Immediately following the shove at 1.40 P.M., March 21st the water overflowed Coleman Street at this point reaching a maximum elevation of 254.7 at point C shortly thereafter. From this time the elevation fluctuated below this maximum until by 3 A.M. on March 24th the water had ceased flowing over the revetment wall.
D In this area the water level reached a maximum elevation of 251.5 at 3 P.M., March 21st but receded to 250.5 at 6 P.M. March 22nd and 23rd the elevation fluctuated between 250.0 and 249.8, and at 3.30 P.M., March 24th the flooding had ceased
E Water flowed over this part of Dundas Street from the afternoon of March 21st to the morning of March 22nd.
F Water flowed over these parts of Dundas Street during the afternoon of March 21st only
G Maximum elevation of water through culvert 249.6 at 6 P.M., March 21st. Elevation 248.1 on March 22nd and 247.9 on March 23rd
H Water at entrance to culvert reached maximum elevation of 249.5 on afternoon of March 21st receding to 249.0 on March 22nd, 248.5 on March 23rd and 248.1 on March 24th
K Water flowed back into river through this ditch, until after the shove at 5.25 P.M., March 24th when the water then flowed west through the ditch to the culvert at H.
L Water flowed over this part of Front Street with a depth varying from 3 to 6 inches from 1.40 P.M., March 21st to 3 P.M., March 24th. The maximum elevation at the North end was 253.0, and 252.9 near Dundas Street
FOOTBRIDGE
CATHERINE ST
JANE ST
CEDAR STREET
EVERETT STREET
RIVER
MOIRA
WEST BRIDGE STREET
LOWER BRIDGE
BRIDGE STREET
COLEMAN STREET
CITY HALL
FRONT STREET
BROCK STREET
JAMES STREET
WILLARD STREET
MARY STREET
COLBORNE STREET
KING
WATER STREET
DUNDAS STREET
DUNDAS
LIMIT OF FLOODED AREA
CANADIAN PACIFIC RAILWAY
CANADIAN NATIONAL RAILWAY
Revetment Wall
Allen's Dock
Bay Bridge Road Culvert
BAY BRIDGE ROAD
VICTORIA PARK
BAY OF QUINTE
5'x10' Culvert
5'x6' Culvert
Proposed by Francis
Levels refer to G.S.C. Mean Sea Level Datum.
MOIRA RIVER, BELLEVILLE, ONT.
PLAN SHOWING FLOOD CONDITIONS.
1920
Scale of Feet.
Made by J.J.B. Checked by F.
Montreal, 20 April 1920.
Walter J. Francis & Company, Engineers,
260 St James Street, Montreal

end of the main jam slid out in an easterly direction and started the movement of the whole jam above this point. This movement was precipitated by a quantity of ice coming downstream from Lazier's Dam.

This shove moved steadily down-stream and came to rest with the front end adjacent to the southerly culvert in the dyke leading to Victoria Park and the rear immediately below the lower, or Cooper's Dam. The exact position of the front and rear of the shove is shown on the plan included as page 17, and the detail of the front of the shove is also shown on page 21. During its passage, the Foot Bridge and the north sidewalk of the Lower Bridge were somewhat damaged but the jam passed the latter with no interference from the piers except the local disturbance of the ice floes. Although the ice grazed against the underside of the girders, the front of the jam passed clearly through the Railway Bridge on the east side to a point opposite the southerly culvert in the dyke leading to Victoria Park, a distance of 300 feet. The shape of the outline of the front of the jam on the east side of the river corresponded exactly with that of the open channel of water which had existed all through the winter, but the ice was prevented from passing into the easterly channel of the river by the dyke connecting Victoria Park with the mainland. The culvert at the south end of the dyke was largely choked with ice and prevented the escape of very much water in that way, and the culvert at the north end of the dyke had been previously blocked, it is stated, by Mr. Jack Roblin. At the extreme west side in the neighbourhood of the bridge, the ice jam did not pass through the bridge but reached only to the bridge piers, having spread out in a

To face page 23.

Photograph No. 10.

Front End of Jam, Looking East.

Taken March 23, 1920

Photograph No. 11.

Front End of Jam, Looking West.

Taken March 22nd, 1920

westerly direction owing to the widening of the river channel at this point. At the centre of the bridge the jam passed through the piers, the front again conforming to the position of the open channel previous to the break-up. It was particularly noticeable that the front of the shove had buckled and broken the bay ice, and that the latter was the cause of the stoppage of the movement.

Photographs Nos. 10 and 11 on page 23, showing the extreme south end of the jam, illustrate the manner in which the river ice attempted to make its way through the bay ice. The upstream side of the railway bridge is shown in photographs Nos. 12 and 13 on page 25, while the downstream side is shown in photographs Nos. 14 and 15 on page 26. In the background of photograph No. 14 the line of the east side of the front of the jam can be distinctly seen with the extreme front at the right-hand side of the picture. In photograph No. 15 it will be noticed that the east side of the jam was piled up against and even attempted to pass over the dyke leading to Victoria Park.

Very important

The Flood.

As the shove above referred to moved downstream, a wave of water came behind it and overflowed the westerly bank of the river over Coleman Street, north of Bridge Street, as shown at A on the plan included as page 21.

On the east side the overflow occurred at a point a little south of the City Hall, and thence continued southerly to the Fire Hall.

When the shove had come to rest the water continued to overflow the

To face page 25.

Photograph No. 12.

Upstream Side of Railway Bridge,

Looking East from West End.

Taken March 21, 1920.

Photograph No. 13.

Upstream Side of Railway Bridge,

Looking West from East End.

Taken March 21, 1920.

To face page 36.

Photograph No. 14.

Downstream Side of Railway Bridge,

Looking South-East from West End of Bridge.

Taken March 21, 1920.

Photograph No. 15.

Downstream Side of Railway Bridge,

Looking North-West from Roblin's Boat-house.

Taken March 22, 1920.

revetment wall on the west side from a point about 200 feet south of Bridge Street to another point a little below Colborne Street from whence it made its way over Water, King, James, Colborne, Mary and Dundas Streets, eventually reaching the railway embankment, partly through the culverts in the roads and partly over Dundas Street. From the railway ditches a portion ran off through the culvert at Bay Bridge Road (G on plan, page 21), another portion through the culvert immediately west of the Railway Bridge, (H on plan, page 21) and the rest back into the river north of the bridge, (K on plan, page 21). Between 3 and 4 o'clock on Sunday afternoon, March 21st, the water reached its maximum height in this area, an elevation of 251.5 (G.S.C. datum), and for a short period was stationary, but it rapidly receded after this time. Photograph No. 16 on page 28, showing the west end of the flooded area, was taken when the flood was at its height. It was noticeable throughout that the culverts under the roads were insufficient to take the water off the flooded land and consequently the water accumulated until it passed over the surface of the roads and onwards to the railway ditches. In fact, this was so obvious that the City Road Superintendent attempted to let the water out of the section north of Dundas Street and west of Mary Street by digging holes in the surface of the former street, as shown in Photograph No. 17 on page 28. After the maximum height of the flood was reached in the middle of Sunday afternoon, the water level in the railway ditches was continuously lower than that north of Dundas Street.

See P49

The water in the new culvert at Bay Bridge Road never rose higher than Elevation 249.6, or within 1.8 feet of the underside of the girders. Photo-

To face page 26

Photograph No. 16.

West End of Dundas Street,

Looking North-East from East of Bay Bridge Road Culvert.

Taken March 21, 1920, 4 p.m.

Photograph No. 17.

West End of Dundas Street,

Looking East from West End.

Taken March 21, 1920, 4 p.m.

graphs Nos. 18 and 19 on page 30, showing this culvert, were taken during the height of the flood.

On the east side of the river the water overflowed the levee at a point a little south of the City Hall, and thence passed over Front Street reaching nearly to Pinnacle Street. Flowing down Front Street the water again reached the river through the subway leading to Victoria Park and down the steps leading to the boat-landing as shown by the arrows on the plan included as page 21. The water reached a maximum elevation of 253.8 at the northerly end of this area and 252.9 in the neighbourhood of Dundas Street, corresponding to a maximum depth of about 6 inches throughout. The condition at the south end of Front Street is shown in photograph No. 20 and a general view looking south along Front Street is shown in photograph No. 21, both on page 31. Both of these views were taken during the afternoon of March 21st.

In addition to the surface flooding described above, a number of cellars were flooded on each side of the river owing to the backing up of the water through the city sewers.

On the following day, that is Monday, March 22nd, there was little change in the river conditions until 5.30 p.m., when a quantity of ice cakes came down the river and caused a general movement of the ice jam. The movement, however, stopped at a point about 300 feet north of the railway bridge. The immediate effect of this was the lowering of the water level on the east side of the river and the raising of the level on the west side, with the result that some additional flooding was caused over Coleman Street north of Bridge Street. During the evening the water was flowing in a southerly

To face page 30.

Photograph No. 18.

Upstream Side of Bay Bridge Road Culvert,

Looking South from Dundas Street.

Taken March 21, 1920, 4.15 p.m.

Photograph No. 19.

Downstream Side of Bay Bridge Road Culvert,

Looking East from West End.

Taken March 21, 1920, 4.15 p.m.

To face page 31.

Photograph No. 20.

Flood on Front Street,

Looking North-West from South End.

Taken March 21, 1920

Photograph No. 21.

Flood on Front Street,

Looking South from below City Hall.

Taken March 21, 1920.

direction over Bridge Street and had collected in the neighbourhood of Everett Street to a depth of about 6 inches. The water gradually receded over this area during the night.

The flow of the river on this date was reported to be 2,900 cubic feet per second.

During the day the Canadian Pacific officials, fearing that the small culvert immediately west of the bridge might become blocked by the large pieces of ice which had collected in the ditch, had a staff of men there continuously blasting the large chunks and taking precautions to prevent blockage of this culvert. The freedom with which the water flowed through is shown in photographs Nos. 22 and 23 on page 33, showing the north and south ends of the culvert respectively on this date. This is also admirably recorded on the moving-picture film which was taken under our direction.

On this same date, namely, March 22nd, the water in the flooded area on the west side of the river, south of Bridge Street, receded considerably and no longer flowed over Dundas Street. The general condition in the neighbourhood of James, Dundas and Water Streets is shown in photographs Nos. 24 and 25, included as page 34.

On Tuesday, March 23rd, there was comparatively little change in the conditions, with the exception of slight fluctuations in the water levels, with a general tendency to drop. The rear of the ice jam was continually changing its position owing to fresh floes of ice coming down the river, and also owing to the frequency of the shoves that were taking place, none of which, however, reached far enough south to affect the conditions at the

To face page 33.

Photograph No. 22.

Small Culvert West of Railway Bridge,

View of North End, Looking South.

Taken March 22, 1920

Photograph No. 23.

Small Culvert West of Railway Bridge,

View of South End, Looking North.

Taken March 22, 1920.

To face page 34.

Photograph No. 24.

East End of Dundas Street and Water Street,

Looking East from Dundas Street.

Taken March 22, 1920.

Photograph No. 25.

Intersection of James and Dundas Streets,

Looking East from Dundas Street.

Taken March 22, 1920.

Railway Bridge or at the front of the jam.

The flow on this date averaged about 3,500 cubic feet per second.

On Wednesday, March 24th, the weather was quite warm, and there was a tendency throughout the day for the jam to settle in new positions. The rear of the jam kept moving down the river until by the afternoon it had reached the Lower Bridge. By 3 o'clock in the afternoon the water level had subsided to such an extent that there was no longer any water flowing over the revetment walls on either side of the river, and within a very few minutes the flooded areas were comparatively dry with the exception of a few pools which had no outlet.

At 5.25 p.m., a large movement of the jam took place through the second and third spans from the west end of the Railway Bridge. This movement started at the rear of the jam, moved steadily through the bridge, spread out on the bay immediately to the south of the bridge and was finally brought to rest by the solidity of the bay ice. There was no movement on the extreme west side of the river, nor on the east side where the ice was undoubtedly firmly grounded on the bed of the river, which is very shallow on the two sides. The movement referred to above followed the deep channel of the river. The rear of the shove at this time was about 200 feet south of the Lower Bridge.

The moving-picture operator was stationed at the west side of the river immediately below the bridge when the above movement took place and took a number of feet of film showing the ice flowing past the bridge.

The next movement took place at 10.45 p.m., and followed the same direction

as at 5.25 p.m., but it was again stopped by the bay ice. Following these larger movements there were frequent small shoves and movements of the ice, until by noon on March 25th the open water reached past the Railway Bridge, with the exception of the two sides where the ice was firmly grounded.

The plan included as page 17 shows the successive stages of the ice movement.

The flow on March 24th averaged about 4,000 cubic feet per second.

The Cause of the Flood of 1920.

As previously stated, the winter months of December, January and February had been of uniform low temperature, with the result that the ice in the bay and river had formed to a thickness considerably greater than usual. Similarly large quantities of ice had formed throughout the length of the Moira River.

With the mild weather that occurred about the 10th of March the ice in the river between Belleville and Corbyville commenced to break up, and at the same time the flow of the river began to increase. By March 16th a large quantity of cake ice in this section of the river had accumulated at the upper end of the City of Belleville. On March 17th the flow of the river increased sufficiently to carry this body of broken ice over Cooper's Dam to a point a little above the Foot Bridge, where it remained for some days until the force of the water and additional ice coming down the river was sufficient to loosen the jam and move the whole field of broken ice downstream until it came to rest in the neighbourhood of the Railway Bridge.

The reasons for the jam occurring in this neighbourhood are very apparent from a study of the local conditions, which are as follows, -

1. The bed of the river from above the Lower Bridge to south of the Railway Bridge is practically level, with the exception of the dredged channel on the west side, consequently the ice movement has a natural tendency to slow up during its passage through this stretch.

2. The river widens out to such an extent that the area of the waterway during winter conditions at the Railway Bridge is twice that at the Lower Bridge, consequently the velocity of flow in the river is correspondingly reduced. (The actual loss of velocity was verified by meter readings).

3. The ice in the Bay of Quinte was of unusual thickness, and with the exception of the narrow channel excavated by the city was solid throughout the bay.

As a result of these conditions, when the river ice with its reduced velocity meets the solid ice of the Bay of Quinte in the vicinity of the Railway Bridge its movement is bound to be arrested.

It has been claimed that the piers of the Railway Bridge tend to aggravate these conditions, but in the present case it will be noticed that notwithstanding the natural loss of velocity of flow of the ice and water the jam was able to pass some 300 feet south of the Railway Bridge on the east side of the river, and to a less extent in the centre of the river. This was owing to the fact that at these places the bay ice was not solid. The front of the jam conformed almost exactly with the outline of the open channel which was there previous to the shove on March 21st. There is no doubt

that if it had not been for the presence of the heavy ice in the bay the shove would have continued somewhat further south and there would have been no flood.

On the east side of the river the ice and water were prevented from passing through the channel east of Victoria Park by the dyke connecting the park with the mainland. This is clearly shown in photograph No. 15 on page 36.

There were originally two openings in this dyke, 37 feet wide, but the one adjacent to the Railway Bridge was replaced by an iron pipe 4½ feet in diameter. We are informed that this pipe had been deliberately closed by Mr. Jack Roblin, while the other opening was to a large extent choked by the front of the jam. There is little doubt that if both these openings had been clear the water level on the east side of the river would have been lower, while the dyke as a whole prevented the flow into the deep channel east of Victoria Park and consequently was largely responsible for the flooding on the east side of the river.

After the jam occurred at this point the water was held at such an elevation that it overflowed the revetment walls on both sides of the river.

Chapter IV

The History of the Floods

In order to make as complete a record of the flooding situation at Belleville for as many years past as possible, we have investigated such sources of reliable information as were available. One of the local newspapers, The Daily Ontario, (formerly The Hastings Chronicle) has a fairly complete file dating back to 1850, which we have examined year by year. In addition, we have obtained data and reports from the Department of Public Works (Canada). The following notes form a brief compilation of such information as is available of former floods, being obtained principally from the newspaper records.

1852 Reference is made on April 8th to the ice being 3 feet thick, and on April 22nd an unusual rise of the river caused much damage, the booms gave way and there were fears for the safety of the Upper Bridge.

1856 Navigation was unusually late and after the opening of navigation on April 26th heavy rains caused the waters of the Moira River to rise to an unusual height resulting in flooding in some districts.

1864 On March 16th the ice piled up against the Grand Trunk bridge and against the Lower Bridge, shoved on March 17th doing much damage all along the river and jammed at the bar. The thick ice in the bay prevented the river ice from moving out.

1865 A flood occurred this year but the records are missing.

1868 On March 18th, after heavy rains the ice between the Upper Bridge and the dam gave way. References are made to the ice being frozen to the bottom and to the ice in the bay being very thick. Mill Street

was flooded and there was water on Front Street 3 or 4 feet deep. On March 23rd the shove lifted the bridge off the piers, levelled the east pier and jammed at the mouth of the river, flooding Front Street and West Belleville.

1870 On March 31st there are editorial references to the fact that anchor ice forms at the bar and causes the flooding of the river. The issues previous to this number are missing but it is probable that there was a flood in this year.

1875 On April 2nd ice came down from the upper part of the city, and caused the flooding of the cellars on Front Street and in the lower part of the city.

1876 On March 10th the water in the river was higher than it had been for years. The shove had taken place two days previously and cellars in the neighbourhood of the river were flooded.

1878 On February 23rd owing to the mild weather and rains, ice which was apparently solid broke up and did much damage to sheds. The east side of the river was flooded as far south as the Lower Bridge but little damage was done on the west side as the water had free passage. Coleman and Bridge Streets were both flooded.

1881 On March 21st the ice jammed at the mouth of the harbour, causing the flooding of Coleman and Cedar Streets. On the following day a further shove caused boat-houses and yachts to be damaged.

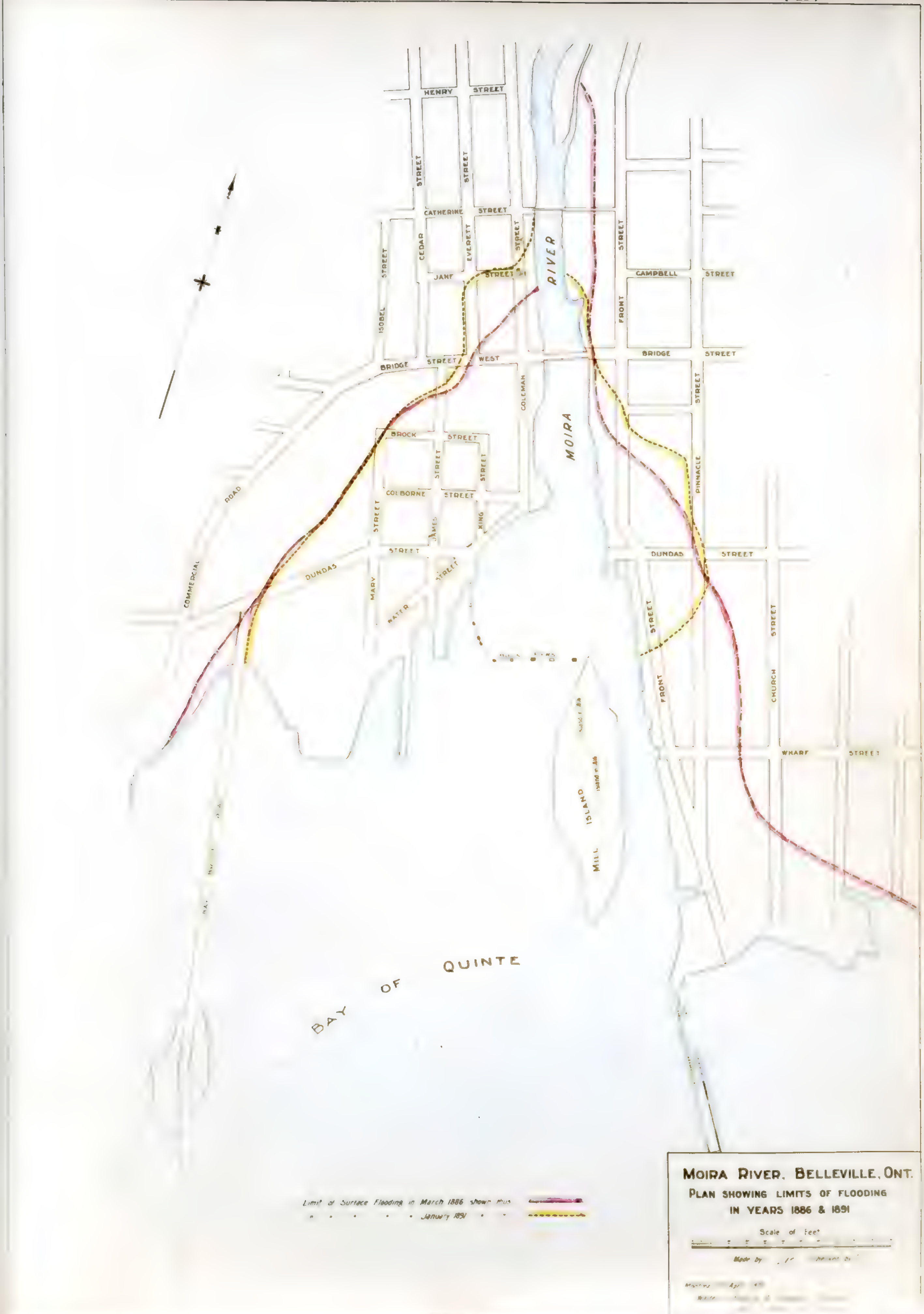
1882 On March 1st reference is made to the flooding of Moira Street but on the following day the ice below the Lower Bridge was carried away to the harbour.

1884 On March 25th the water backed up at the Lower Bridge on account of the mouth of the river being choked. The lower part of Front Street was flooded. Reference was made previous to this of there being little danger of damage provided the ice in the harbour did not prevent the river ice going out.

1885 to 1889 - The files are missing.

1886 The newspaper records for this year are missing and a report made by the District Engineer of Public Works has also been lost, but there are in existence plans showing the limits of the flooding, from which the drawing included as page 41 has been compiled. Photographs Nos. 26 and 27 included as page 42 were said to have been taken "about 35 years ago", and in all probability were of this flood, which was considerably greater in extent than any that occurred for a number of years.

1887 In later editions of the papers there are references to the flood


HENRY STREET
STREET
STREET
CATHERINE STREET
STREET
CEDAR
EVERETT
STREET
ISOBEL
JANE STREET
RIVER
CAMPBELL STREET
FRONT
STREET
BRIDGE STREET WEST
BRIDGE STREET
COLEMAN
MOIRA
STREET
PINNACLE
BROCK STREET
STREET
STREET
COLBORNE STREET
STREET
JAMES
KING
DUNDAS STREET
DUNDAS STREET
ROAD
COMMERCIAL
DUNDAS
MARY
STREET
WATER
STREET
FRONT
STREET
CHURCH
WHARF STREET
ISLAND
MILL
BAY OF QUINTE
Limit of Surface Flooding in March 1886 shown thus
January 1891
MOIRA RIVER, BELLEVILLE, ONT.
PLAN SHOWING LIMITS OF FLOODING
IN YEARS 1886 & 1891
Scale of Feet

To face page 42.

Photograph No. 26.

View showing Flood Conditions on Brock Street,

Probably taken March, 1886.

Photograph No. 27.

View showing Flood Conditions on Bridge Street, West.

Probably taken March, 1886.


WINDSOR H

of this year.

1890 On February 21st the river overflowed the banks on the west side along south Coleman Street, and on the following day a reference is made to a man cutting a channel near the lighthouse and also to the flooding of Front Street.

1891 On March 24th reference is made to the amount of damage done during the flood, but the complete account is apparently lost.

On April 6th of this year the District Engineer of the Department of Public Works (Canada) made a report on the flood in which he made the following statement, - "The condition of flood is very much like the one in January, 1886, the cause is however different. In 1886 the flood was due to the accumulation of "Anchor or frasil ice" under the surface, or solid ice at the mouth of the river, extending from this point out into the bay some 900 feet below the railway pier, which obstructed the run of the water from the river, and the surface ice being lifted formed a dam. The present flood is caused by the ice, which first grounded on the east side of the river, and in the shallow bed of the stream, forming with the assistance of Mill Island and the piers of the Corporation boom, an ice jam."

1892 The Government caused channels to be cut in the ice on each side of the island to divert the force of the ice and carry it into the bay. There was probably no flood this year but the file is incomplete.

1893 On March 29th the ice came down from as far as Corbyville and ultimately caused the flooding of the banks from the east and west sides of the river.

1894 On March 8th there were two shoves accompanied by much flooding.

1894 to 1910 - The files are missing.

1908 On February 22nd the District Engineer of the Department of Public Works (Canada) again made a report on the flooding situation, which occurred on February 19th. In this year apparently the flood was confined to the east side of the river and was caused by the grounding of anchor ice. It was also stated in the District Engineer's report that a partial cause of the formation of anchor ice was the existence of boom piers in the river near Mill Island and that it was proposed to move these piers in the spring of that year.

1910 On March 7th the ice jam came down from above Lott's Dam and lifted the Lower Bridge. All premises along the east bank of the river from the Upper Bridge to the lower Fire Station were affected,

every cellar being flooded to a depth of several feet. The stone revetment walls saved property as the ice only went over at two places. The water ran over Front Street at the lower Fire Hall. No reference is made to the location of the front of the jam or to there being any flooding on the west side of the river.

1911 On March 27th the ice shoved from the Foot Bridge to Panter's Park on the west side of the river, south of the Lower Bridge, but there was no rise of the river and no cellars were flooded.

1912 Apparently the ice went easily out of the river causing only a little flooding of the Front Street stores and dwellings.

1913 On March 15th the break-up started in the north end of the city flooding the entrance to the Foot Bridge. Later, the jam passed down to a point midway between the Lower Bridge and the Railway Bridge, but the water did not overflow the revetment walls.

At this time there was considerable agitation by the City of Belleville for a change in the type of railway bridge, particularly in order that subways might be provided at each end of the bridge.

1914 On March 27th the rush of ice damaged the Upper Bridge and passed through the city coming to rest with the front end considerably south of the north end of Victoria Park. The ice was nearly up to the bridge girders, and water poured over the banks on both sides of the river.

1915 There was no flood.

1916 Serious floods occurred throughout the winter.

1917 There was no flood.

1918 A serious flood occurred at the end of March.

1919 There was no flood.

Summary.

With the exception of certain years, the records of the exact conditions during the floods are very incomplete, and do not date back to the period previous to the placing of logging boom piers across the mouth of the river,

the location of which is shown on the plan included as page 41. The records show, however, that floods caused by ice conditions have been common occurrences for many years and the newspapers contain frequent references to the bay ice and to dams of anchor ice being the cause of the flooding. It appears that definite steps were taken to mitigate conditions after the serious flood of 1886. In 1887 and in 1890 the Public Works Department (Canada) dredged a channel extending from a point about 300 feet north of the present railway bridge southerly into the Bay of Quinte for the purpose of providing a deep waterway for the passage of the ice and flood waters from the Moira River. This, however, proved of little effect as a serious flood again occurred in 1891. No further remedial measures were undertaken until about the year 1906 when the Harbour Commissioners of the City of Belleville built dry masonry revetment walls along each side of the river from the Lower Bridge extending south to a point near the present location of the railway bridge. The east wall was 1,316 feet long and the west, 890 feet. These walls reached up to about the level of the natural ground surface and were primarily intended to prevent damage by keeping the ice within the limits of the river. About this same time, the city officials built a causeway or dyke connecting Mill Island (now Victoria Park) with the mainland, leaving, under instructions from the Department of Public Works, two openings 37 feet in width.

In 1906 the logging boom piers were removed from across the mouth of the river, as it was thought that they were largely contributory to the formation of the ice jam at the mouth of the river.

The piers of the Canadian Northern Ontario Railway bridge were erected in 1911, and it is noteworthy that during the three years that there were no piers

of any description across the mouth of the river, there occurred a flood, namely in 1910. The newspaper records do not state where the front of the jam occurred in this year, but judging from the statement that the water overflowed the banks near the Fire Hall, there is little doubt that the jam was in the neighbourhood of the present railway bridge.

After the railways had built the bridge the floods continued intermittently as before, but it is of special significance that in the flood of 1914 the front of the jam went past the Railway Bridge and did not stop until it was considerably south of the north end of Victoria Park.

Chapter V

Responsibility for the Flood

Although the flood of 1920 was caused by a jam which occurred in the neighbourhood of the Railway Bridge, it must be borne in mind that floods have frequently occurred when the jam took place in other parts of the river. A jam occurring north of the Foot Bridge would not usually cause a flood, but if it occurred at any point south of the Foot Bridge there was always liability of the water overflowing either bank of the river. It is a fact, however, that there is no probability of a flood occurring unless there is an ice jam, as it is not a large quantity of water that creates flooding conditions but rather the blocking of the channel by the piling up of broken ice. It is remarkable that in some years when the flow of the river was abnormally high, no floods occurred, while in other years when the flow was correspondingly low there were floods. Furthermore, even when the conditions are all favourable for a jam to take place the actual location where it will occur cannot be predicted. Again, although it can safely be said that the ice movement under certain conditions will not take place further south than the point of commencement of the solid bay ice, it is impossible to predict where the ice jam will actually occur as this depends on a combination of conditions which can neither be controlled nor foreseen.

In the event of the jam occurring at any other place than the vicinity of the Railway Bridge it could not be claimed that it was caused by any other

than perfectly natural circumstances, but in the case of the jam stopping near the Railway Bridge attempts have been frequently made to place the responsibility solely on the bridge. In fact, after the flood of this year, the City Council of Belleville went to the length of passing a resolution to this effect.

After considerable study of the conditions causing and affecting the jam, we have come to the definite conclusion that the Railway Bridge does not in any way contribute to these conditions, but that in the event of the ice in the Bay of Quinte being solid the jam is bound to stop in this neighbourhood. Consequently, we are of the opinion that no responsibility should be placed on the railway companies for causing or even tending to cause the ice jam.

Statements have been made that owing to the shadow of the bridge the ice forms to a greater thickness under the bridge than elsewhere, and also that as the railway companies do not cut away the ice from around the piers this heavy barrier of ice stops the shove. This year the ice under the bridge was somewhat thicker than in the open, but owing to the falling of the water the ice had broken away from the piers to a large extent. A similar condition prevailed at the Lower Bridge where the easterly pier, at the time of the shove on March 21st, was solidly embedded in ice 3 feet thick, but at this point, owing to the slope of the river and the comparatively narrow channel, there was sufficient velocity of flow to carry the ice shove past this bridge with little or no interference. Furthermore, where the bay ice south of the Railway Bridge was not solid the shove went past the bridge with the greatest ease.

It would even appear that the effect of the bridge piers is to break up the large floes of ice, thus helping rather than hindering the ice movement.

Another phase of the subject is the effect of the railway embankment leading to the west end of the Railway Bridge. In the year 1918 there is no doubt that this embankment somewhat aggravated the flood conditions on the west side of the river, as the water had practically no outlet until it reached sufficient elevation to pass over the railway tracks. This year, however, owing to the construction of the culvert at Bay Bridge Road there is no question but that the conditions were very different. For a short period on Sunday afternoon, March 21st, the water remained over the surface of Dundas Street and was possibly held by the railway embankment, but as soon as the ditches and culverts became clear of the winter's accumulation of snow and ice they were able to take off all the water that came over Dundas Street, and by Monday morning the water level was reduced to such an extent throughout that the surface of Dundas Street was entirely above the water level. From this time on the water level in the railway ditches was at all times lower than the water level north of Dundas Street. Both the Bay Bridge Road culvert and the small culvert immediately west of the Railway Bridge were able to take all the water that came into the railway ditch throughout the period of the flood without causing any backing up on Dundas Street.

In view of these facts we are of the opinion that the embankment was not responsible for any material aggravation of the flood conditions on the west side of the river.

We have gathered that some of the residents in the flooded area are basing

their claims on statements that the culvert immediately west of the Railway Bridge was blocked, as proved, according to their claim, by the fact that the railway forces had to blast away the ice obstruction. This, however, was not the case as the blasting that was done was carried out purely as a preventative measure.

Chapter VI

Remedial Measures

In view of the fact that the railway companies are unlikely to be held responsible for floods that are caused by ice jams occurring north of the Railway Bridge, we understand that it is not your desire that we should report upon means of preventing floods under this condition. There is, however, the question of the effect of the railway embankment to the west of the Railway Bridge, which has a bearing on the situation regardless of the cause of the flood. We have already expressed our opinion that this year the railway embankment did not materially aggravate the flood condition. There is a possibility, however, that in the event of a more severe flood occurring than that of this year, a quantity of water might reach the embankment greater than the combined capacity of the two culverts. We think that the future possibilities of very serious floods being aggravated by the embankment can be positively avoided by enlarging the small wood-box culvert immediately west of the Railway Bridge to about 6 feet wide by 5 feet high and also by the construction of an additional culvert of about 10 feet span by 5 feet high in the neighbourhood of James Street. There is no doubt, however, that before such additional works are undertaken by the railway companies the city should provide culverts in suitable locations and of ample dimensions through the roadways.

The situation is somewhat different with regard to remedial measures for jams occurring in the neighbourhood of the Railway Bridge. Although the bridge is not responsible for the ice jam, we believe that it is advisable for the railways to take steps to positively avoid any possibility of a charge of responsibility for the floods.

There are a number of ways in which the ice jams may be avoided, or as an alternative, there are ways in which the overflowing of the banks may be prevented. The majority of the methods such as the building of dams to retain the ice or the building of high waterproof retaining walls, or dredging or attempts to keep large open channels in the river, are all objectionable on account of their excessive original cost and expense of operation. We are of the opinion, however, that the ice jams can be positively prevented from occurring in the immediate vicinity of the railways by preventing the solid bay ice from forming in a comparatively limited area above and below the Railway Bridge. This might be done in different ways, but a way not involving considerable capital outlay would be that of employing one or two men continuously throughout the winter months to break up the surface ice as it formed. If an area extending 100 feet north and say, 400 feet south of the bridge were kept free in this manner, there is no doubt that if the ice above reached as far south as this open water it would continue steadily past the bridge, sufficiently, in all probability, to prevent any flood, or certainly to prevent any charge of responsibility against the railway companies. We also believe that if the city authorities of Belleville were approached they would contribute towards the expense of such work as it would undoubtedly be of benefit to the people of Belleville.

Chapter VII

Conclusions and Recommendations

Briefly summarizing the foregoing report, we beg to state that we have come to the following conclusions, -

1. That the Railway Bridge was in no way responsible for the ice jam or flood of 1920.

2. That the railway embankment west of the Railway Bridge did not materially aggravate the flood conditions.

3. That the culverts immediately west of the Railway Bridge and near the Bay Bridge Road were both of sufficient capacity to prevent any backing up of the water in their immediate vicinity, but that they would not be of sufficient capacity if a much larger quantity of water were to reach the railway ditches than the quantity of this year.

4. That if there had been no dyke connecting Victoria Park with the mainland there would have been no flood on the east side of the river.

5. That the blocking of the culvert immediately south of the Railway Bridge through the dyke referred to above materially aggravated the flood condition on the east side of the river.

6. That on account of the topographical features at the mouth of the river there is a natural tendency for the shove to come to rest in the neighbourhood of the Railway Bridge. This tendency becomes a certainty when the ice in the bay is solid.

7. That the remedial works heretofore carried out, namely, dredging, revetment walls, removal of boom piers, and the promiscuous cutting of the ice in the bay, have not had the desired effect because they have not remedied the cause of the trouble.

8. That the ice jams and consequent floods have been occurring for many years, regardless of whether there were bridge or boom piers in the river mouth or not, and unless more effective remedial measures than those of the past are employed they will continue to do so in the future.

We also beg to make the following recommendations, -

1. That the culvert immediately west of the Railway Bridge be replaced by a larger one with an opening about 8 feet wide and 5 feet high, and also that an additional culvert with an opening about 10 feet wide and 5 feet high should be constructed in the neighbourhood of the James Street crossing, together with a suitable outlet to the bay, south of the tracks.

2. That the heavy surface ice be prevented from forming in an area extending 100 feet north and 400 feet south of the Railway Bridge, by employing one or two men to devote the whole of their time during the winter months to breaking up the surface ice as it forms.

3. That the City of Belleville be approached with the request to participate in the cost of such work of keeping an open waterway.

The whole respectfully submitted,

Walter J. Francis & Company,

per Walter J. Francis

Montreal, April, 1920.

40 sq ft
50 sq ft

bel
bel
148 sq ft proposs - double 8x8
concrete culvert